Examiners' Report
Principal Examiner Feedback

October 2022

Pearson Edexcel International Advanced Level
In Physics (WPH16) Paper 1
Practical Skills in Physics II

General

The IAL paper WPH16 Practical Skills in Physics II assesses the skills associated with practical work in Physics and builds on the skills learned in the IAL paper WPH13. This paper assesses the skills of planning, data analysis and evaluation which are equivalent to those that A level Physics students in the UK are assessed on within written examinations. This document should be read in conjunction with the question paper and the mark scheme which are available at the Pearson Qualifications website, along with Appendix 10 in the specification.

In this specification, it is expected that students will carry out a range of Core Practical experiments. The skills and techniques learned will be examined in this paper but not the Core Practical experiments themselves. Students who do little practical work will find this paper more difficult as many questions rely on applying the learning to novel as well as other standard experiments.

It should be noted that, whilst much of the specification is equivalent to the previous specification, there are some notable differences. Students are expected to know and use terminology appropriately, and use standard techniques associated with analysing uncertainties. These can be found in Appendix 10 of the specification. In addition, new command words may be used which to challenge the students to form conclusions. These are given in Appendix 9 of the specification, and centres should make sure that students understand what the command words mean.

The paper for October 2022 covered the same skills as in previous series and was therefore comparable overall in terms of demand.

Question 1

This question was set in the context of investigating the magnetic field produced by a current-carrying coil. The use of an oscilloscope to measure potential difference is found in Core Practical 11: Capacitor Discharge.

In part (a) students had to describe a safety issue and how it should be dealt with. Although this question was aimed at the lower end of the grade scale, very few students scored both marks. Some students noted that the plastic could melt without referring to the wire. Those that scored marks either stated that the wire could overheat or there was a risk of electrocution, such as in the example below. Some students stated using a low potential difference or a resistor in the circuit as a way of dealing with the issue. However, students tended to describe general issues with using electric circuits, such as not using near water, rather than relating their answer to the apparatus shown.

(a) Describe one safety issue and how it should be dealt with.

(2)

~~For~~ If current increases in wire, the wire overheats and there is chance of current ~~leakage~~ burns if we touch the wire. ~~Wear~~ ~~Ris~~ also there is a risk of shock if there is any damage in plastic tube. so ~~dont~~ use gloves and stay at a distance.

In part (b) students had to explain why vernier calipers would be better than a metre rule to measure the distance between the two coils. As is often the case with "Explain" questions, students seem reluctant to write in full sentences and rely on using mathematics. Although this is a standard style of question used in many previous series this was not done well. Centres should note that the number of marks may change for this type of question therefore students may not gain credit for certain answers. The first mark required students to state the resolution of the two instruments therefore this should be in words not implied from a calculation. Centres should note that the term precision is not equivalent to resolution in this specification, therefore students will not be awarded the mark if this term is used. Some students stated an incorrect resolution for the vernier calipers, maybe as the distance was given in cm rather than mm. In addition, units were sometimes missing. For the second mark, students should have calculated the percentage uncertainty for both instruments as a comparison was needed for the conclusion. Students must use the **half resolution** for this calculation. The final mark was dependent on a valid comparison, either between two correct resolutions stated or two correct percentage uncertainties. The example below shows a good answer to this question.

Explain why using Vernier calipers would be better than a metre rule to measure *r*.

You should include calculations in your answer.

(3)

The vernier caliper ~~has~~ resolution ~~of~~ is 0.1 mm and meter ~~has~~ rule is 1 mm.
The ~~resolut~~ resulation is smaller with vernier calipe, Hence, percentage uncertainty is less ~~not~~ than meter rule.

with vernier caliper $\%U = \frac{5\times10^{-3}}{2} \times 100$ = 0.25%   with meter rule $\%U = \frac{0.05}{2} \times 100$ = ~~57~~ 2.5%

1cm 10 mm 0.1 $\frac{5\times10^{-2}}{2} \times 100 = 0.05\%$ $\%U = \frac{0.05}{10} \times 100 = 0.5\%$

In part (c) students had to describe how to determine an accurate value for the maximum e.m.f. from the trace on the oscilloscope screen. It was clear that students were unfamiliar with using an oscilloscope to measure potential difference. In addition, some students did not use words to describe the process but presented a calculation. Most students that scored a mark stated how to use the 100 mV per division setting. The most common error was describing how to determine the time period rather than the amplitude of the trace. Some students used the term “adjacent peaks” which implies a horizontal rather than vertical measurement. The final mark was for including a technique to improve the accuracy of the measurement of amplitude. This was not scored very often. The following example was judged to be clear enough for all three marks.

Describe how an accurate maximum value for E can be determined from the oscilloscope screen.

(3)

The maximum value of E can be found out by measuring the highest amplitude by division and then multiplied by 100mV per devision. This can be done for few points, and a mean can be calculated.

In part (d) students had to criticise the recording of the data. This was much more familiar to students although some referred to the range or the uneven intervals in the values of *E,* such as in the example below.

Criticise the recording of this data.

(2)

Not all the values have the same significant figure.
There's no gradual decrease in the value. the values aren't consistant.

Question 2

This question assessed planning skills within the context of investigating how the volume of liquid inside a transparent tube decreased as liquid flowed out of the tube. Although this is an unusual context, the formula is similar to Core Practical 11: Capacitor Discharge.

In part (a) students had to explain why a graph of ln V against t should be used to test the relationship, which was in the form of an exponential. This type of question should be very familiar however there may a slightly different emphasis that students should be aware of. The first mark was for performing a correct log expansion of the given formula. There are only two forms this can take, either a power law such or an exponential function. However, some students did not complete this successfully. For the second mark students had to compare their log expansion with y = mx + c, which is standard for this type of question. The most common error here was not writing this in the same order as the log expansion. Students then had to identify the gradient correctly as -b. Some students missed the - sign, and some referred to “m” rather than state “the gradient is”. Most students were not awarded the mark as most only stated the gradient was *-b*. This would be correct if the question had asked how the log graph would lead to a value for *b*. However, the question asked why the graph should be used to test the relationship, therefore an indication that this would lead to a straight line was needed either by stating this directly or stating the gradient is constant. The following example shows a student referring to a straight line directly.

(a) Explain why a graph of ln V against t should be used to test this relationship.

(2)

$$V = V_0 e^{-bt}$$

$$\ln V = -bt + \ln V_0$$

$$y = mx + c$$

graph should be a straight line with a gradient -b and a y-intercept of $\ln V_0$

Part (b) was the familiar planning question although this was worth fewer marks as normal as the graph had already been given in part (a). Some students repeated their answer to part (a) here which was not needed. Students should be aiming to write a method for the investigation described in the question that could be followed by a competent physicist. Although marks were not awarded for linking ideas, students often suffered as their use of language was imprecise or their descriptions became muddled making their intentions unclear. The best answers were well structured and concise, leading to a method that could be followed easily.

The mark scheme for this type of the question can vary owing to the context of the experiment however they all follow a similar structure. The first three marks were dedicated to collecting an accurate set of values, in particular identifying when to start timing, measuring at fixed intervals of time or volume, and how to measure volume correctly. Most students should be able to achieve at least one of these marks, but many did not.

The final mark was for another technique appropriate to the investigation. Most stated that a stopwatch should be used to measure time. Those that referred to the use of a video camera scored the mark if they were specific in how to use the video for recording the time. As is usual, students recite "repeat and take a mean" without any thought as to how this should be done in the context of the investigation, therefore were not credited. The following example illustrates this well and only scored the final mark for the use of a stopwatch.

(4)

· Place a stopwatch near the ~~[illegible]~~ scale and take reading of both ~~[illegible]~~ volume and time ~~[illegible]~~ salmantaniously
· Use a stopwatch to measure the time, t.
· Plot a graph of ln V againt t, which will give a straight line (negetive).
· Repeat the measurement and calculate the mean.

In part (c) students had to explain a source of uncertainty in this investigation. This is a very difficult skill aimed at the highest grades. As is usual for this type of question, students made general remarks about reaction time without relating it to the investigation. The following example shows how reaction time should be related directly to the experiment, which scored both marks.

(c) Explain a source of uncertainty in this investigation.

(2)

human reaction time could cause a random error, as there will be a slight delay between reading time from stopwatch then taking the corrosponding reading for volume

Question 3

This question involved plotting and analysing the graph of the data for the saturated vapour pressure of a liquid at different values of absolute temperature. A question involving a graph appears in each series with a common mark scheme. Therefore, there is plenty of opportunity to practise this skill and consult Examiner's Reports to correct common errors. A good student should be able to access most of the marks and most students should score some marks.

Part (a)(i) assessed the students' ability to process data and plot the correct graph, i.e. log P against $\frac{1}{T}$. The first two marks were for processing the data correctly and was awarded most often. The number of decimal places given should be sufficient to plot a graph on standard graph paper. For logarithms students should give a minimum of two decimal places although three is accepted. Some students converted the pressure in kPa into Pa which was not necessary and may result in a more awkward graph to plot. In addition, the question asked for log values of P. Where the relationship is in the form of a power law, logs to different bases are accepted. However, the relationship was not in this form, therefore only log to base 10 was accepted. The most common errors here were truncating rather than rounding, and using an inconsistent number of decimal places in processed data. Occasionally, students gave log values for both variables.

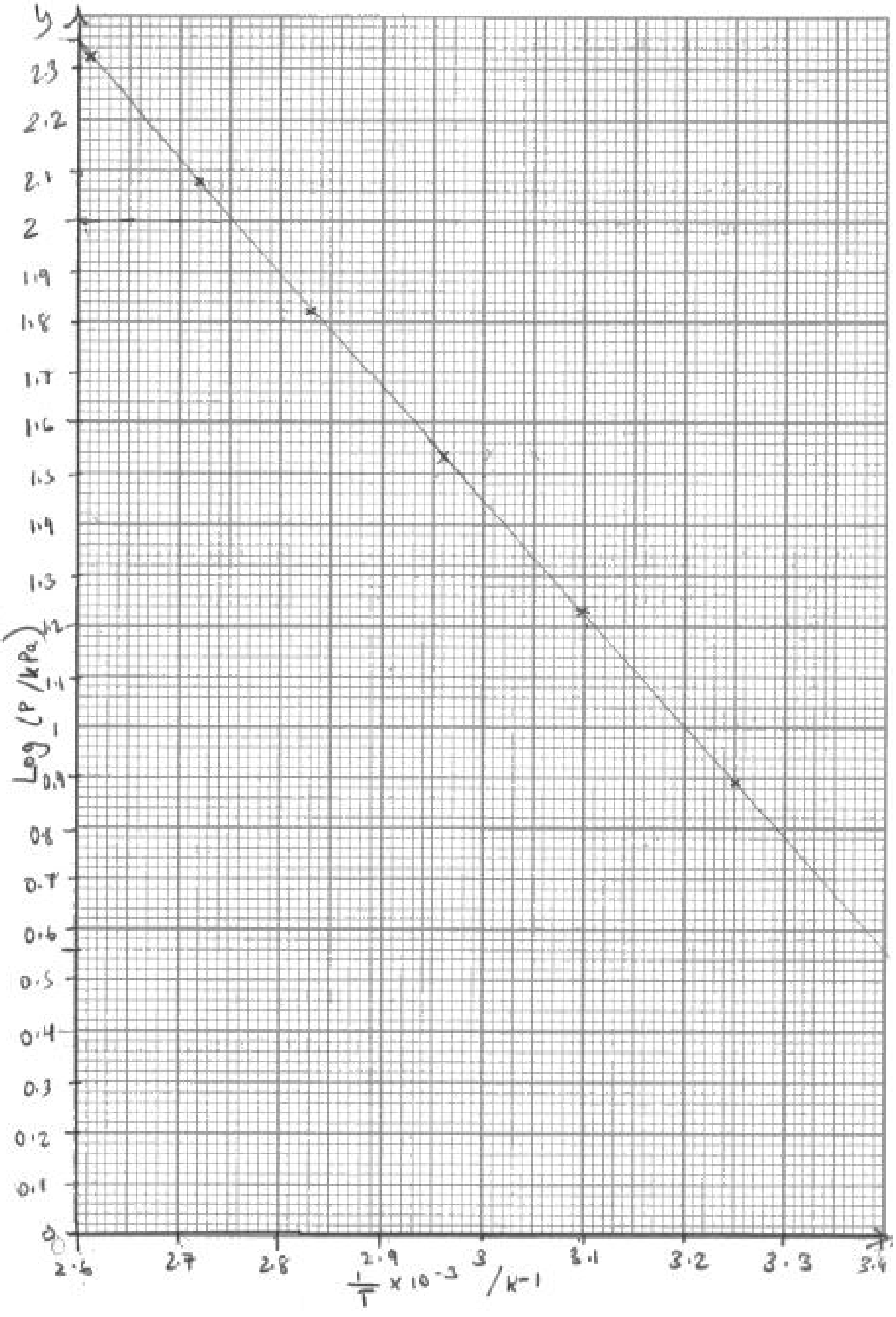
The third mark was for placing the axes the correct way around and labelling with the correct quantity. Some students inverted the axes, i.e., they plotted $\frac{1}{T}$. against log P. Students should note that the question is always written in the form "plot y against x". This also often lead to mistakes in later parts. The most common mistake is not using the correct format for labelling a log axis, either by missing out the brackets or units or both. The correct form is log (quantity/unit), e.g. log (P / kPa). In addition, some students either missed out or incorrectly used the factor of 10^{-3}, or forgot to include the correct unit on the x-axis.

The fourth mark was for choosing an appropriate scale. At this level, the students should be able to choose the most suitable scale in **values of 1, 2, 5 and their multiples of 10** such that the plotted points occupy **over half**

the grid in both directions. Students should realise that although the graph paper given in the question paper is a standard size the graph does not have to fill the grid, and a landscape graph can be used if it produces a more appropriate fit. In most cases it is unnecessary. Students at this level should also realise that scales do not have to start from zero and scales based on 3, 4 (including 0.25) or 7 are awkward and not accepted. Students should also be encouraged to label every major axis line, i.e. every 10 small squares, with appropriate numbers, so that examiners can easily see the scale used. Occasionally, students mislabelled their axes so that the scale appeared to change.

The fifth mark is for accurate plotting. Students should be encouraged to use neat crosses (× or +) rather than dots when plotting points. Students were not awarded this mark if they used large dots that extended over half a square or used an awkward scale. Mis-plots were seen, and students should be encouraged to check a plot if it lies far from the best fit line.

The final mark is for the best-fit line. This mark was awarded often as the data used did not produce a significant scatter. Often students will join the first and last points instead of judging the scatter of the data points which can lead to errors. Where students were not awarded this mark it was either because the line was too thick, i.e. over half a small square, or were not continuous. Students should be encouraged to use a 30 cm rule for for this examination. The following is a perfect example of a best fit line which is not straight but composed of two shorter lines joined in the centre. This graph is otherwise a good example and scored the rest of the marks.



y
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Log (P/kPa)
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
3.4
1/T x 10-3 /K-1

In part (a)(ii) students were asked to determine a value for the gradient. There were several common errors seen. Many students used the first and last points, or other data points from the table. This is only acceptable if the data points lie **exactly** on the best fit line. Students should be encouraged to find places where the best-fit line crosses an intersection of the grid lines near the top and bottom of the best-fit line and **to mark these on the graph**. Those that used awkward scales were often only successful when sensible values were used. Students also often forgot to use the factor of 10^{-3} from the x-axis. The final mark could be awarded from an incorrect gradient, but often students omitted the - sign. The following example shows a student using the first and last points in the calculation, but these were lying on the best fit line.

(ii) Determine the gradient of the graph.

(3)

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$m = \frac{2.3 - 0.9}{(2.61 \times 10^{-3}) - (3.25 \times 10^{-3})}$$

$$m = -2187.5$$

Gradient = -2190

In part (b)(iii) students had to use their value of the gradient to calculate a constant from the formula given. Students were largely successful with this, but those that did not score often used the incorrect value of *k*. The following example shows how the above gradient was used successfully.

Determine the value of X in joules.

(3)

$$-2187.5 = \frac{X}{2.30\,k}$$

$$X = -2187.5 \times 2.3 \times 1.38 \times 10^{-23}$$

$$X = -6.94 \times 10^{-20}\ \text{J}$$

$X =$ 6.94×10^{-20} J

Finally, in part (b) students had to determine the boiling point of the liquid in °C. Those that realised that this required interpolating from the graph often scored full marks. This part was often left blank, possibly as a relationship was not included for students to substitute values into. Students should realise that any calculation in this question will rely on using data from the graph. The following example shows a good answer to this question, and the student had marked the interpolation on the graph which made it easier to check the correct value was used.

Determine the boiling point of the liquid in °C when the atmospheric pressure is 100 kPa.

(3)

$\log P = \log 100$

$\log P = 2$

when $\log P$ is 2, $1/T$ is 2.75×10^{-3}

$\therefore \quad T = 1/2.75 \times 10^{-3}$

$T = 363$ K

T in °C = 363 − 273 = 90°C

Boiling point = 90 °C

Question 4

This question involved determining a value for the resistivity and resistance of constantan wire using two different methods. This involved the use of a micrometer screw gauge to measure diameter which students encountered in two AS core practicals. In addition, the analysis of uncertainties is common to all past papers therefore students should be encouraged to analyse uncertainties on a regular basis, either whilst making measurements or using past papers. Students should read Appendix 10 of the specification and **include all working** as marks are awarded for the method.

Part (a)(i) was familiar question in which students had to **explain** a technique when using a micrometer screw gauge for measuring the diameter of a wire. As is usual in this type of question, many students only described the technique but did not link them to a particular type of error, or gave two techniques instead of the one the question asked for. It is also expected that students give enough detail in relation to the context of the experiment for each technique. Therefore, for a repeated measurement it is expected that the student describes where or how to take the repeated measurement. Often, students omitted "at different orientations" or words to that effect. For the concept of the zero-error associated with a piece of apparatus, it is expected that students state that it must be corrected for not just checked. Some students referred to parallax which is not relevant. The second mark was for linking the technique to its type of error. Students who attempted this did it well, although it should be noted that a random error can only be reduced not eliminated. The following student explained two techniques but scored both marks from the first explanation. The second explanation would only have scored the first mark as systematic is spelt incorrectly. Although phonetic spellings are accepted, the word "systemic" has a different meaning and is not accepted.

(i) Explain one measuring technique he should use.

(2)

- Take measurement from several orientations and then repeat and calculate the mean to reduce random error.
- Check and correct for ~~e~~ zero error to eliminate systemic ~~error~~ error.

Part (a)(ii) involved calculating a mean and uncertainty from a set of data. The first mark was for the correct value of the mean given to the **same number of decimal places as the measurements**. Many students gave too many decimal places. The second two marks were for the uncertainty calculation. The students **must show** the uncertainty calculation for the second mark, and this is awarded for calculating the **half range or furthest from the mean**. A small number of students used the first and last values given in the table instead of the highest and lowest values. Some students also calculated the percentage uncertainty. The final mark was for the correct uncertainty given to the same number of decimal places as the mean. The following student clearly shows their working, including the answers rounded to the correct number of decimal places.

Determine the mean value of d_x and its uncertainty in mm.

(3)

$$\text{Mean} = \frac{0.31 + 0.32 + 0.31 + 0.33 + 0.30}{5}$$

$$= 0.314$$

$$\text{Uncertainty} = \frac{0.33 - 0.30}{2} = 0.015$$

Mean value of d_x = 0.31 mm ± 0.02 mm

In part (b)(i) students were given a set of measurements for another wire and asked to show that the resistivity of the metal was about 5 ´ 10^{-7} Ω m. Most students did this well as this is part of the AS specification. However, the most common issue was not using the correct formula for the cross-sectional area or using an incorrect formula. Power of ten errors were also common as SI units were not used. The following example shows clear working leading to a correct answer.

(i) Show that the resistivity ρ of the metal is about $5 \times 10^{-7}\ \Omega\,\text{m}$.

(3)

$$I = V/R \qquad R = \frac{\rho l}{A} \qquad A = \pi r^2$$

$$R = V/I \qquad \rho = \frac{AR}{l} \qquad = \pi \times \left(\frac{0.22}{2} \times 10^{-3}\right)^2$$

$$R_{\cancel{Total}} = \frac{4.990}{0.457} \qquad = \frac{\pi \times (1.1 \times 10^{-4})^2 \times 10.9}{0.894}$$

$$= 10.9\ \Omega \qquad = 4.63 \times 10^{-7}\ \Omega\text{m}$$

$$\approx 5 \times 10^{-7}\ \Omega\text{m}$$

In part (b)(ii) they were asked to **show that** the uncertainty in the area resistivity was about 9%. This required the students to show a full calculation as the first two marks were awarded for the method. The final mark was for the **correct** final answer given to one more figure than 9%, which was often omitted. It should be noted that the final value varied slightly owing to rounding. Students used two methods of solving this, either by combining percentage uncertainties, or by using the maximum and minimum method. Combining percentage uncertainties was more common and lead to more correct answers. However, some students did not calculate the percentage uncertainty for all variables, and some calculated the percentage uncertainty in the radius incorrectly. The following student did the calculation correctly in one step. Although this is acceptable as it is clear, it can be more prone to errors.

(ii) Show that the percentage uncertainty in ρ is about 9%.

(3)

$$\left(\frac{0.005}{4.99} + \frac{0.005}{0.457} + \frac{0.1}{89.4} + 2\left(\frac{0.01}{0.22}\right)\right) \times 100$$

$$\%U = 9.4\ \%$$

In part (c) students were given measurements of resistance using an ohmmeter and a formula for calculating a resistance from these values. Students were then asked to show that the percentage uncertainty in this value of resistance was about 2%. Although the value was given, some students calculated it again which was not given any credit. The most common error here was using the full resolution rather than the half resolution for the uncertainty in the measurements. Many students also added percentage uncertainties, rather than adding the uncertainties, which resulted in a similar answer. Those that used the full resolution without the factor of 2 given in the formula could not be awarded marks as the method was incorrect. The following is a clear example of how to calculate this correctly.

$$R_L = 2 \times (R_2 - R_1)$$

Show that the percentage uncertainty in R_L is about 2%.

$R_L = 11.4\,\Omega$

(3)

$\%$ Uncertainty $= \dfrac{\text{Uncertainty}}{\text{value}} \times 100$

$\Rightarrow R_L = \underline{2 \times (10.2 - 4.5)} \Rightarrow 11.4$

$\Rightarrow \dfrac{2\left(\left(\frac{1}{2} \times 0.1\right) + \left(\frac{1}{2} \times 0.1\right)\right)}{11.4} \times 100 = 1.75\%$

$\approx 2\%$

In part (d) the students were given calculated values for the resistivity and resistance with their percentage uncertainties, along with published values. Students had to comment on how well the calculated values confirmed that the metal was constantan. This is a standard type of question used in every series but there were a significant number that did not attempt this. Those that did often scored well using one of the two different methods. Students **must show their calculations** as marks are awarded for the method and the final value may differ slightly owing to different levels of rounding.

The first method was calculating the limits for both values. The main error was adding the percentage uncertainty as a number rather than as a percentage. A smaller number used the percentage difference method. This is an approximate method and should only be used when an uncertainty on the measurements is not available. However, this is accepted but can produce more errors, most notably using the calculated value or a mean of the quoted values in the denominator rather than just one of the quoted values. This is shown in the example below where the student has used the calculated value for ρ in the denominator.

You must include calculations in your answer.

(3)

value of ρ student calculated is too close

% difference = ~~$\frac{4.6\times10^{-7}}{4.7\times10^{-7}}$ = $\frac{4.6\times10^{-7}}{4.7\times10^{-7}}$ =~~

~~$4.7 - 4.6 = \frac{0.1}{4.6} \times 100 = 2\%$ difference.~~

$4.9 - 4.6 = 0.3$ $\quad \frac{0.3}{4.6} \times 100 = 6.5\%$

and for Value of R $\quad 11.4 - 11.2 = 0.2$

$\frac{0.2}{11.2} \times 100 = 1.8\%$ which is too close.

For both methods, the final mark was for a correct conclusion. As in previous series, the main error with the conclusion was not explicitly making a comparison between values. The above example shows no direct comparison, in this case to the percentage uncertainties given. The example below does have a clear comparison of limits to the published values and a correct conclusion.

You must include calculations in your answer.

(3)

$4.6 \times 1.09 = 5.014$

$11.4 \times 0.98 = 11.172$

$4.6 \times 0.91 = 4.186$

$11.4 \times 1.02 = 11.628$

$4.186 < 4.9 < 5.014$

$11.172 < 11.2 < 11.628$

published values for R_L and ρ are inside range of values

Summary

Students will be more successful if they routinely carry out and plan practical activities for themselves using a wide variety of techniques. These can be simple experiments that do not require expensive, specialist equipment. In particular, they should make measurements on simple objects using Vernier calipers and micrometer screw gauges and complete all the Core Practical experiments given in the specification.

In addition, the following advice should help to improve the performance on this paper.

- Learn what is expected from different command words, in particular the difference between describe and explain.
- Use the number of marks available to judge the number of separate points required in the answer.
- Be able to describe different measuring techniques in different contexts and explain the reason for using them.
- Show working in all calculations.
- Choose graph scales that are sensible, i.e. 1, 2 or 5 and their powers of ten only so that at least half the page is used. It is not necessary to use the entire grid if this results in an awkward scale, i,e. in 3, 4 or 7. Grids can be used in landscape if that gives a more sensible scale.
- Plot data using neat crosses ($\times$ or $+$), and to draw best fit lines. Avoid simply joining the first and last data points without judging the spread of data.
- Draw a large triangle on graphs using sensible points. Labelling the triangle often avoids mistakes in data extraction.
- Learn the definitions of the terms used in practical work and standard techniques for analysing uncertainties. These are given in Appendix 10 of the IAL specification.
- Revise the content of WPH13 as this paper builds on the knowledge from AS.